The temperature 85° C. was probably chosen because it may be relied upon with certainty to kill pathogenic organisms, especially the tubercle bacillus. We believe, however, that a temperature of 65° C., acting for twenty minutes, is sufficient to kill the tubercle bacillus, and that, therefore, pasteurised milk, *i.e.*, milk heated to 68° C. for twenty minutes, is quite safe, and certainly its flavour is almost unaltered. We are aware, of course, that some observers claim that tuberculous milk may retain its infective properties after pasteurisation, but the work of Theobald Smith seems to explain the contradictory results which have been obtained. He found that tubercle bacilli suspended in water, saline solution, bouillon or milk were destroyed at 60° C. in 15—20 minntes. If, however, a pellicle forms on the milk, then the tubercle bacilli in the pellicle seem to be protected, and may survive an hour's heating at 60° C. (*Journ. Exper. Med.*, iv, 2, p. 217).

NEW SYNTHESES OF SOME DIUREIDES.

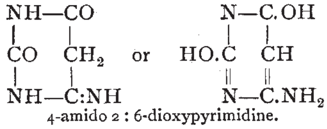
W. TRAUBE publishes in the present number of the *Berichte* further details on the new syntheses of uric acid, xanthine and the methyl derivatives of the latter—theobromine, theophylline and caffeine. The starting point is either cyanacetic acid or its ester. Cyanacetic acid and urea in presence of phosphorus oxychloride form cyanacetyl urea,

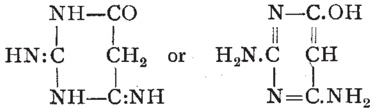
$$NH_2.CO.NH.CO.CH_2CN.$$

Also cyanacetic ester and guanidine combine with the separation of alcohol, forming cyanacetyl guanidine,

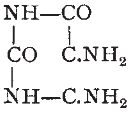
$$NH_2C(:NH).NH.CO.CH_2.CN.$$

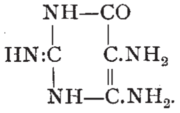
The further treatment of these two compounds is similar. With alkalis they are converted into cyclic (pyrimidine) compounds. Cyanacetyl urea forms 4-amido-2 : 6-dioxypyrimidine, whilst cyanacetyl guanidine gives 2 : 4-diamido-6-oxypyrimidine


4-amido 2 : 6-dioxypyrimidine.

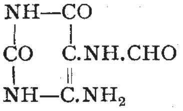

2 : 4-diamido-6-oxypyrimidine.

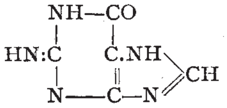
They are then treated with nitrous acid, which replaces the hydrogen of the methylene group by an "isonitroso" group, and this group is then reduced to the "amido" group by ammonium sulphide, yielding the following compounds :



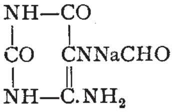


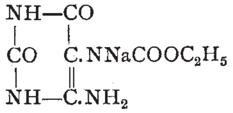
Boiled with formic acid, the first is converted into a formyl derivative and the second directly into guanine,



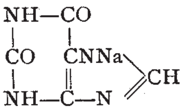


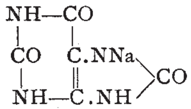
If chloroformic ester is used in place of formic acid, the first yields a urethane. Both formyl derivative and urethane form sodium salts, which, when heated, yield the sodium compound of xanthine,





and that of uric acid respectively,


Sodium xanthine.


Sodium urate.

Guanine may be readily converted by Fischer and Strecker's method into xanthine, and by methylation into theobromine and caffeine, whereas by using methyl urea in the formation of cyanacetyl urea in the first method, or by methylating the formyl compound, theobromine, theophylline, caffeine and the corresponding uric acids may be produced. A patent has been taken out by the discoverer for these processes.

ARTIFICIAL RAIN.[1]

THE question perpetually arises in the popular mind as to whether man cannot produce rain or drought according as his needs may dictate. The possibility of doing this is never questioned by barbarians, who have their professional rain makers and great medicine men, and superstitiously attribute to them all power over nature. In some parts of the Christian world it has been believed that man could bring about rain or drought, not by his own power, but by intercession with the Creator, who would, perhaps, work a miracle on his behalf. During the past thousand years miracles have been confessedly rare, and some consider it almost impious for a man to dare to interfere with the operations of nature on a large scale; some even refuse to be doctored for disease.

The recognition of the truths revealed by modern science has made it evident that man can affect the weather only by understanding and making use of the laws of nature. He must do it in a natural or scientific way, not through any supernatural power or in any miraculous way. In fact, those who have a very imperfect knowledge of the laws of nature, if any at all, are often inclined to believe that there really must be some process known to science, or still to be discovered, by which man can bring abundant rain from the clouds when and where he needs it. They point to the popular belief that rain follows great battles, as proving that there is some way by which to affect the clouds—it may be through the noise of the battle, or it may be the burning of the gunpowder, or it may be a possible electric disturbance. They point to the reputed influence of lightning rods, which are supposed to draw the lightning from the skies and prevent the formation of hail.

In these and other matters there is abundant room for self-deception. It would be a great mistake to conclude that any battle by reason of its noise, or heat, or gunpowder has had any effect in the way of producing rain, or that the lightning rods have had any effect in producing or preventing hail. The statistics that are supposed to substantiate such conclusions do not really prove anything of the kind, and yet many are deceived by them because in reasoning upon the phenomena of nature they forget to apply the simplest laws of logic, and are carried away by emotions or preconceived opinions or the plausible suggestions of others. This is not at all singular, for the history of man's progress in knowledge is the history of a long series of mistakes covering thousands and tens of thousands of years. All have to learn by bitter experience, and if science seems to have made rapid progress during the past century, that should not blind our eyes to the fact that errors may still prevail among the professional men of science as well as the rest of mankind.

In the special matter of the artificial formation of rain we heartily endorse the statement that if it is in any way possible to bring this about we must labour to discover it; in fact, we eventually shall discover the way, if there be one, but thus far nothing has been accomplished to justify us in believing that feasible methods exist or are likely to exist. Various methods have had their advocates both in Europe and America, and the citizens of the United States, with a nervous energy that is greatly to be admired, have given a full and fair trial, at great expense, to several methods advocated by men of imperious natures that would brook no denial short of nature's own experimental demonstration of their errors. Thus the rain-making by explosives was most thoroughly tested by order of Congress at an expense to the public of many thousands of dollars, and the results have been discussed sufficiently, both in public and private, to show that nothing in the way of rain, and probably nothing in the way of cloud or mist, was produced. One of the first experimental trials was made quite near Washington, D. C., at night-time, November 2–3, 1892, when a series of clouds with showers were passing over the neighbouring country, and these continued right along for several hours

---

[1] Abridged from a contribution by Prof. Cleveland Abbe to the U.S. *Monthly Weather Review.*

© 1900 Nature Publishing Group

quite independent of the bombardment. The reports from numerous observers showed that as the showers moved along over the earth's surface those in front of it reported that the noise of the exploding dynamite occurred just before the shower; those in the wake of the shower reported that the shower came before the explosion, while those in the midst of the shower, of course, heard the explosion while it was raining. There was no evidence that the explosion had any effect on the clouds. Careful observations in Washington, D.C., during the whole of this first experiment, and during subsequent experiments with explosives, warranted the conclusion that no rainfall was produced by bombardment.

About that time a "rain wizard" commenced operating in Ohio. His method consisted in locking himself in a barn, house, luggage van or other room, wherein he made a fire and burned or evaporated certain chemicals, the smoke of which rose through the roof out of some impromptu chimney or stove-pipe and dissipated itself in the thin air. Of course it was claimed that the chemicals exerted a great influence on the atmosphere and forced rain to come. Occasionally rain did come after one, two, or three days of a chemical performance, but equally often it did not come. The Weather Bureau was often importuned for advice as to when the wizard should be called to any given town, and whether the inhabitants would be justified in paying him his fee of several hundred dollars. Eventually, a prominent railway company rigged up a car for his use, and during the years 1892-4 made it convenient for all the citizens on its lines to invoke the aid of "the rain producer." Of course there were numerous cases in which the operations were followed by rain; those who studied the Daily Weather Map could see at a glance that these rains accorded with the general weather conditions and had nothing to do with the rain-making operations. So long as frequent rains occurred, although they were natural and were predicted by the Weather Bureau on the basis of the weather map from day to day, yet the farmers of Iowa, Kansas and Nebraska, ignoring this fact, were sure to accredit all success to the wizard.

During the last great drought in California, 1898-1899, the citizens of one city authorised an extensive and expensive system of experiments by gases and by cannon, but were fortunately saved the necessity of actually wasting their money by the fact that an abundant rain fell naturally just before they were ready to begin their own operations.

Occasionally we still receive newspaper items reviving the old story that floods of rain were broken up by cannonading at Rome, or that rain was produced by cannonading in Italy, or that hailstorms were averted from a special vineyard that was protected by lightning rods while neighbouring vineyards suffered. These are all repetitions of the same old myths, or repetitions of useless experiments, and the intelligent reader may dismiss them as having no foundation. No matter how severely his land may be suffering from drought or flood, he should seek some other mode of relief and not waste his time and money in efforts to change the nature of the clouds or the atmosphere.

ON THE STATISTICAL DYNAMICS OF GAS THEORY AS ILLUSTRATED BY METEOR SWARMS AND OPTICAL RAYS.[1]

IMAGINE a cloud of meteors pursuing an orbit in space under outside attraction—in fact, in any conservative field of force. Let us consider a group of the meteors around a given central one. As they keep together their velocities are nearly the same. When the central meteor has passed into another part of the orbit, the surrounding region containing these same meteors will have altered in shape; it will in fact usually have become much elongated. If we merely count large and small meteors alike, we can define the density of their distribution in space in the neighbourhood of this group; it will be inversely as the volume occupied by them. Now consider their deviations from a mean velocity, say that of the central meteor of the group; we can draw from an origin a vector representing the velocity of each meteor, and the ends of these vectors will mark out a region in the velocity diagram whose shape and volume will represent the character and range of deviation. It results from a very general proposition in dynamics that as the central meteor moves along its path the region occupied by the group of its neighbours multiplied by the corresponding region in their velocity diagram remains constant. Or we may say that the density at the group considered, estimated by mere numbers, not by size, varies during its motion proportionally to the extent of the region on the velocity diagram which corresponds to it.

This is true whether mutual attractions of the meteors are sensibly effective or not; in fact, the generalised form of this proposition, together with a set of similar ones relating to the various partial groups of coordinates and velocity components, forms an equivalent of the fundamental principle of Action which is the unique basis of dynamical theory.

Now, suppose that the mutual attractions are insensible, and that W is the potential of the conservative field: then for a single meteor of mass m and velocity v we have the energy $\frac{1}{2}mv^2 + m\mathrm{W}$ conserved: hence if δv_1 be the range of velocity at any point in the initial position, and δv_2 that at the corresponding point in any subsequent position of the group, we have $v_1 \delta v_1 = v_2 \delta v_2$, these positions remaining unvaried and the variation being due to different meteors passing through them. But if $\delta\omega_1$ and $\delta\omega_2$ are the initial and final conical angles of divergence of the velocity vectors, corresponding regions in the velocity diagram are of extents $\delta v_1 . v_1^2 \delta\omega_1$ and $\delta v_2 . v_2^2 \delta\omega_2$: these quantities are, therefore, in all cases proportional to the densities at the group in its two positions. In our present case of mutual attractions insensible, the volume density is thus proportional to $v\delta\omega$, because $v\delta v$ remains constant. Now the number of meteors that cross per unit time per unit area of a plane at right angles to the path of the central meteor is equal to this density multiplied by v: thus here it remains proportional to $v^2\delta\omega$, as the central meteor moves on. In the corpuscular formulation of geometrical optics this result carries the general law that the concentration in cross-section of a beam of light at different points of its path is proportional to the solid angular divergence of the rays multiplied by the square of the refractive index, which is also directly necessitated by thermodynamic principles; as a special case it limits the possible brightness of images in the well-known way.

In the moving stream of particles we have thus a quantity that is conserved in each group—namely, the ratio of the density at a group to the extent of the region or domain on the velocity diagram which corresponds to it; but this ratio may vary in any way from group to group along the stream, while there is no restriction on the velocities of the various groups. If two streams cross or interpenetrate each other, or interfere in other ways, all this will be upset owing to the collisions. Can we assign a statistical law of distribution of velocities that will remain permanent when streams, which can be thus arranged into nearly homogeneous groups, are crossing each other in all directions, so that we pass to a model of a gas? Maxwell showed that if the number of particles each of which has a total energy E is proportional to $e^{-\mathrm{hE}}$, where h is some constant (which defines the temperature), while the particles in each group range uniformly, except as regards this factor, with respect to distribution in position and velocity jointly, as above, then this will be the case. In fact, the chance of an encounter for particles of energies E and E′ will involve the product $e^{-\mathrm{hE}} e^{-\mathrm{hE}'}$ or $e^{-\mathrm{h}(\mathrm{E}+\mathrm{E}')}$, and an encounter does not alter this total energy $\mathrm{E}+\mathrm{E}'$; while the domains or extents of range of two colliding groups each nearly homogeneous and estimated, as above, by deviation from a central particle in position and velocity jointly, will have the same product after the encounter as before by virtue of the Action principle. It follows that the statistical chances of encounter, which depend on this joint product, will be the same in the actual motion as are those of reversed encounter in the same motion statistically reversed. But if the motion of a swarm with velocities fortuitously directed can be thus statistically reversed, recovering its previous statistics, its molecular statistics must have become steady; in fact, we have in such a system just the same distribution of encountering groups in one direction as in the reverse direction: thus we have here one steady state. The same argument, indeed, shows that a distribution, such that the number per unit volume, of particles whose velocity deviations correspond to a given region in the velocity diagram, is proportional to the extent of that region without this factor $e^{-\mathrm{hE}}$, will also be a steady one. This is the case of equable distribution in each group as regards only the position and velocity diagrams conjointly; but in this case each value of the resultant velocity would occur with a frequency

---

[1] A paper read by Dr. J. Larmor, F.R.S., before Section A of the British Association at Bradford, September, 1900.

© 1900 Nature Publishing Group